



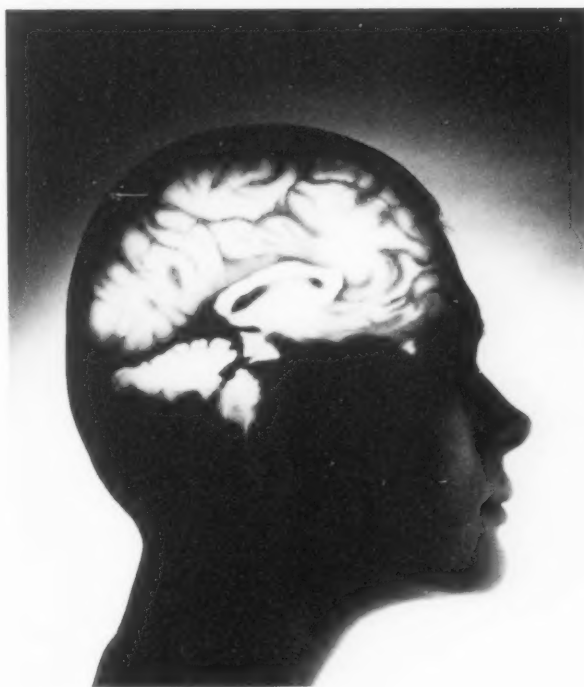
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Surveillance for Traumatic Brain Injury Deaths — United States, 1989–1998



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Surveillance for Traumatic Brain Injury Deaths — United States, 1989–1998

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Abstract

Problem/Condition: Data indicate that approximately 50,000 U.S. residents die as a result of traumatic brain injury (TBI) annually. Survivors of TBI are often left with neuropsychologic impairments that result in disabilities affecting work or social activity. During 1979–1992, TBI-related death rates declined 22%, from 24.6 to 19.3 deaths/100,000 population. This report describes the epidemiology and trends in TBI-related mortality during 1989–1998.

Reporting Period: January 1, 1989–December 31, 1998.

Description of Systems: The National Center for Health Statistics (NCHS) Multiple Cause of Death public use data were analyzed for this study.

Results: During 1989–1998, an annual average of 53,288 deaths (range: 51,848–54,501) among U.S. residents were associated with TBI. TBI-related death rates declined 11.4%, from 21.9 to 19.4/100,000 population. The major causes of TBI-related deaths were firearm-related (40%), motor-vehicle-related (34%), and fall-related (10%). The leading causes of TBI-related deaths differed among age groups. Among youths aged 0–19 years, motor-vehicle-related TBIs were the leading cause; among persons aged 20–74 years, firearm-related TBIs were the leading cause; and among persons aged ≥75 years, fall-related TBIs were the leading cause. Comparing rates in 1989 with rates in 1998, motor-vehicle-related causes declined by 22%; the majority of this decline occurred during the first 5 years of the period. During 1989–1998, firearm-related TBI-related deaths declined by 14%; approximately all of this decline occurred during the last 5 years of the period. In contrast, fall-related TBI-related death rates increased by 25% during the period.

Conclusion: This analysis of mortality data identifies recent trends in TBI-related deaths occurring during 1989–1998. Fall-related TBI death rates have increased throughout the period. Firearm-related TBI death rates, which were increasing in the early 1990s, declined. Motor-vehicle-related TBI death rates, which were decreasing until the mid-1990s, have since demonstrated only a limited change.

Public Health Action: More current population-based epidemiologic studies of TBI are needed to assess recent trends of etiologic factors, provide additional guidance for public policy, and evaluate prevention strategies. Despite the decline in fatal TBI incidence, TBI morbidity and mortality remains a public health challenge. Public health, law enforcement, and transportation safety professionals can address these challenges by implementing effective interventions based on a thorough assessment of the factors that influence health-related behaviors.

Introduction

Traumatic brain injury (TBI) is a major cause of morbidity and mortality in the United States (1–18). Each year, approximately 50,000 deaths in the United States are associated with TBI (19), representing >33% of all injury-related deaths. Among survivors of TBI, neuropsychologic and other disabilities (20) are common and often require extensive rehabilitation services and sometimes long-term care. TBI

results in substantial loss to persons, their families, and society (21–23); in 1995, the total direct and indirect financial costs of these injuries were estimated at \$56 billion (23).

In 1989, the Federal Interagency Head Injury Task Force identified traumatic brain injury as a critical public health problem (24). Since 1989, CDC has published analyses of trends in TBI mortality (1,5,19); the most recent of these indicated that TBI mortality rates decreased from 24.6 to 19.3

deaths/100,000 population during 1979–1992, a decline of 22% (19). This decline in mortality was accompanied by changes in distribution of the major external causes (i.e., the circumstance or environmental event that caused the injury) of TBI-related death, such that firearm-related injury surpassed motor-vehicle-related injury as the leading cause of TBI-related deaths in 1990. In 1995, CDC developed guidelines for surveillance of TBI (25) and, with funding authorized under Public Law 104-166 (the Traumatic Brain Injury Act of 1996), supported development of a multistate TBI surveillance system (26,27).

This analysis examines more recent trends in TBI mortality. Specifically, this analysis of mortality data 1) characterizes secular trends of TBI-related deaths during 1989–1998, 2) describes differences in risk for death by age, sex, and race, 3) identifies populations at the greatest risk, and 4) describes trends among the leading external causes of TBI-related death: firearm-related injury, motor-vehicle-related injury crashes, and fall-related injury. Data tabulations are also provided to serve as reference material.

Methods

Data Source

Data from CDC's National Center for Health Statistics (NCHS) Multiple Cause of Death public use data files were analyzed (28) for January 1, 1989–December 31, 1998. These mortality data were compiled from death certificates submitted from the vital records offices of all 50 states and the District of Columbia. Causes of death were recorded on the death certificate by the attending physician, medical examiner, or coroner by using a format specified by the World Health Organization and endorsed by CDC (29).

Case Definition

Cases of TBI deaths were identified and selected where ≥ 1 diagnostic code representing TBI (25) was included in the sequence of conditions contributing to death. These diagnostic codes comprised the following *International Classification of Diseases, 9th Revision* (ICD-9) (29) codes:

- 800, fracture of vault of skull;
- 801, fracture of base of skull;
- 803, other skull fracture;
- 804, multiple fractures involving skull or face with other bones;
- 850, concussion;
- 851, cerebral laceration and contusion;

- 852, subdural, subarachnoid, and extradural hemorrhage after injury;
- 853, other unspecified intracranial hemorrhage after injury;
- 854, intracranial injury, not otherwise specified;
- 905.0, late effects of fracture of the skull and face;
- 907.0, late effects of intracranial injury without skull fracture; and
- 873, other open wound to the head.

For injuries and poisoning, ICD-9 (29) specified that the underlying cause is coded rather than the nature of injuries. Therefore, the suffix “-related” was added to describe TBI external causes (e.g., firearm-related, motor-vehicle-related, and fall-related TBIs). The underlying cause of death is defined as 1) the disease or injury that initiated the chain of morbid events leading directly to death or 2) the circumstances of the accident or violence that produced the fatal injury (29). For all deaths, the underlying cause is selected from conditions reported in the medical certification section of the death certificate.

Stratifying and Calculating Rates

External causes of TBI mortality were categorized on the basis of ICD-9 external cause-of-injury codes (i.e., E codes) as follows:

- motor-vehicle-related (E810–E825);
- fall-related (E880–E886, E888);
- firearm-related (E922, E955.0–E955.4, E965.0–E965.4, E970, E985.0–E985.4); and
- other or unspecified causes (all other E codes).

Additionally, reported death rates are further subcategorized for firearm-related injuries: suicide (E955.0–E955.4) and homicide (E965.0–E965.4).

Race-specific fatal TBI rates for the three race categories with the highest incidence of TBI (i.e., black, American Indian/Alaska Native, and white) were calculated, as well as sex- and age-specific rates. These rates were based on U.S. resident estimates from population microdata files maintained by the U.S. Bureau of Census for individual years (30). Age-adjusted rates were standardized to U.S. census population estimates for 2000 by direct method. Calculations of age-adjusted and age-specific rates excluded cases with missing age data ($N = 511$); the latter were included in the calculation of crude rates. Appropriate 95% confidence intervals were calculated for the rates on the basis of standard errors for random variation in the number of deaths each year, as recommended by NCHS (31). Linear regression was used to determine the significance of decline during the interval and

the decline of specific external causes of death (e.g., motor-vehicle-related, firearm-related, and fall-related TBIs). Differences with p values <0.05 were considered statistically significant.

Results

TBI-Related Deaths by Age, Sex, and Race

During 1989–1998, an annual average of 53,288 deaths among U.S. residents were associated with TBI, for a rate of 20.6/100,000 population (range: 51,848–54,501) (Table 1). During this interval, TBI-related death rates declined 11.4%, from 21.9 to 19.4/100,000 ($p < 0.0001$).

Age Groups

The TBI-related death rate for the surveillance period was highest among persons aged ≥ 75 years (Figure 1). During 1989–1998, TBI-related death rates declined in all age groups

aged <75 years (Table 2), but death rates increased for persons aged ≥ 75 years from 50.0/100,000 to 60.5/100,000 (21%).

FIGURE 1. Average annual death rates of traumatic brain injury, by age and sex — United States, 1989–1998

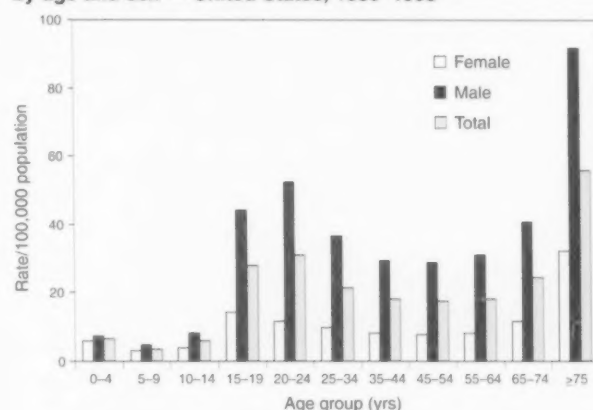


TABLE 1. Annual numbers and age-adjusted rates/100,000 population for traumatic brain injury deaths, by year, sex, and race — United States, 1989–1998

Year		White			Black			American Indian/ Alaska Native			Other			Total		
		No.	Rate	95% CI*	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
1989	All	45,169	21.4	21.2–21.6	7,941	26.6	26.0–27.2	601	30.6	27.8–33.3	790	13.1	12.0–14.1	54,501	21.9	21.7–22.1
	F	11,323	10.3	10.1–10.5	1,796	11.2	10.7–11.7	163	16.0	13.3–18.6	243	7.9	6.8–9.1	13,525	10.4	10.2–10.5
	M	33,846	34.3	33.9–34.6	6,145	45.1	43.9–46.4	438	46.6	41.5–51.7	547	18.7	16.8–20.7	40,976	35.2	34.9–35.6
1990	All	44,948	21.2	21.0–21.4	8,131	26.8	26.1–27.4	574	28.6	26.0–31.2	779	12.6	11.5–13.6	54,432	21.7	21.5–21.9
	F	11,103	10.0	9.8–10.1	1,728	10.7	10.2–11.3	124	12.5	10.1–14.9	227	7.3	6.2–8.3	13,182	10.0	9.8–10.2
	M	33,845	34.0	33.6–34.4	6,403	46.0	44.8–47.3	450	45.8	40.9–50.8	552	18.5	16.6–20.4	41,250	35.1	34.7–35.4
1991	All	44,240	20.8	20.6–21.0	8,495	27.3	26.7–27.9	531	25.8	23.4–28.2	823	12.0	11.1–13.0	54,089	21.4	21.2–21.6
	F	10,923	9.7	9.5–9.9	1,795	10.9	10.4–11.4	138	13.0	10.7–15.3	221	6.6	5.6–7.6	13,077	9.8	9.6–10.0
	M	33,317	33.3	33.0–33.7	6,700	46.9	45.7–48.2	393	39.6	35.2–44.1	602	18.0	16.3–19.8	41,012	34.6	34.3–35.0
1992	All	42,250	19.7	19.5–19.9	8,277	26.0	25.4–26.6	486	23.8	21.5–26.1	835	11.9	11.0–12.9	51,848	20.3	20.2–20.5
	F	10,385	9.2	9.0–9.3	1,787	10.6	10.1–11.1	127	12.3	10.0–14.6	253	7.5	6.5–8.6	12,552	9.3	9.2–9.5
	M	31,865	31.7	31.3–32.0	6,490	44.4	43.2–45.5	359	36.1	31.9–40.3	582	16.7	15.1–18.3	39,296	32.9	32.6–33.2
1993	All	43,602	20.1	19.9–20.3	8,696	27.1	26.5–27.7	562	26.5	24.1–28.8	866	11.6	10.7–12.4	53,726	20.9	20.7–21.0
	F	10,996	9.6	9.4–9.7	1,884	11.1	10.6–11.6	149	13.3	11.0–15.5	268	7.4	6.4–8.4	13,297	9.7	9.6–9.9
	M	32,606	32.2	31.8–32.5	6,812	46.0	44.8–47.2	413	40.7	36.3–45.1	598	16.1	14.6–17.6	40,429	33.6	33.2–33.9
1994	All	43,708	20.0	19.9–20.2	8,452	26.0	25.4–26.6	617	28.2	25.9–30.6	940	12.2	11.3–13.1	53,717	20.7	20.5–20.9
	F	10,871	9.4	9.2–9.6	1,837	10.8	10.3–11.3	156	13.5	11.3–15.7	284	7.3	6.4–8.2	13,148	9.5	9.4–9.7
	M	32,837	32.2	31.9–32.6	6,615	44.0	42.9–45.2	461	44.1	39.7–48.5	656	17.7	16.2–19.3	40,569	33.5	33.1–33.8
1995	All	43,435	19.7	19.6–19.9	7,808	23.9	23.4–24.5	619	26.9	24.7–29.1	971	12.2	11.4–13.1	52,833	20.2	20.0–20.3
	F	11,167	9.5	9.3–9.7	1,790	10.4	9.9–10.9	172	14.5	12.3–16.8	283	7.0	6.1–7.9	13,412	9.6	9.5–9.8
	M	32,268	31.3	31.0–31.7	6,018	40.1	39.0–41.2	447	39.5	35.6–43.3	688	18.1	16.6–19.7	39,421	32.2	31.9–32.5
1996	All	43,483	19.6	19.4–19.8	7,751	23.5	23.0–24.1	580	25.8	23.6–28.0	949	11.6	10.7–12.4	52,763	20.0	19.8–20.1
	F	11,407	9.6	9.4–9.7	1,798	10.4	9.9–10.9	146	13.0	10.8–15.2	283	6.9	6.0–7.8	13,634	9.6	9.5–9.8
	M	32,076	31.0	30.6–31.3	5,953	39.0	37.9–40.0	434	39.1	35.1–43.1	666	17.0	15.5–18.4	39,129	31.8	31.5–32.1
1997	All	43,475	19.4	19.2–19.6	7,394	22.3	21.8–22.8	633	29.4	27.0–31.9	961	11.4	10.6–12.1	52,463	19.7	19.5–19.8
	F	11,736	9.7	9.5–9.9	1,730	10.0	9.5–10.4	153	13.9	11.6–16.2	321	7.4	6.5–8.3	13,940	9.7	9.6–9.9
	M	31,739	30.4	30.0–30.7	5,664	36.9	35.8–37.9	480	46.3	41.7–50.8	640	16.0	14.6–17.3	38,523	31.0	30.7–31.3
1998	All	43,895	19.3	19.2–19.5	7,045	21.2	20.7–21.7	621	26.7	24.5–28.9	945	10.9	10.2–11.7	52,506	19.4	19.3–19.6
	F	12,060	9.8	9.6–10.0	1,619	9.3	8.8–9.7	184	15.7	13.4–18.1	307	6.7	5.9–7.5	14,170	9.7	9.6–9.9
	M	31,835	30.2	29.9–30.5	5,426	35.4	34.4–36.4	437	38.5	34.6–42.5	638	16.1	14.7–17.5	38,336	30.6	30.3–30.9
All years	All	438,205	20.1	20.1–20.2	79,990	25.0	24.8–25.2	5,824	27.2	26.5–27.9	8,859	11.9	11.6–12.2	532,878	20.6	20.6–20.7
	F	111,971	9.7	9.6–9.7	17,764	10.5	10.4–10.7	1,512	13.8	13.1–14.5	2,690	7.2	6.9–7.5	133,937	9.8	9.7–9.8
	M	326,234	32.0	31.9–32.2	62,226	42.2	41.8–42.5	4,312	41.5	40.2–42.9	6,169	17.2	16.7–17.7	398,941	33.0	32.9–33.1

* Confidence interval.

TABLE 2. Annual numbers and rates/100,000 population for traumatic brain injury deaths, by year, age group, and sex — United States, 1989–1998

Year		Age											
		0–4 yrs			5–9 yrs			10–14 yrs			15–19 yrs		
		No.	Rate	95% CI*	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
1989	All	1,461	7.9	7.5–8.3	847	4.7	4.4–5.0	1,160	6.9	6.5–7.3	5,643	31.1	30.3–31.9
	F	659	7.3	6.7–7.8	328	3.8	3.3–4.2	345	4.2	3.8–4.7	1,408	15.9	15.1–16.8
	M	802	8.5	7.9–9.1	519	5.7	5.2–6.1	815	9.5	8.8–10.1	4,235	45.6	44.2–46.9
1990	All	1,394	7.4	7.0–7.8	781	4.3	4.0–4.6	1,113	6.5	6.1–6.9	5,681	32.0	31.2–32.8
	F	606	6.6	6.1–7.1	296	3.4	3.0–3.7	343	4.1	3.7–4.5	1,299	15.0	14.2–15.8
	M	788	8.2	7.6–8.7	485	5.2	4.8–5.7	770	8.7	8.1–9.4	4,382	48.1	46.7–49.5
1991	All	1,418	7.4	7.0–7.8	716	3.9	3.6–4.2	1,111	6.3	5.9–6.7	5,584	32.4	31.6–33.3
	F	650	6.9	6.4–7.5	286	3.0	2.6–3.4	295	3.4	3.0–3.8	1,319	15.7	14.9–16.6
	M	768	7.8	7.3–8.4	430	4.8	4.4–5.3	816	9.0	8.4–9.6	4,265	48.2	46.8–49.7
1992	All	1,264	6.5	6.1–6.8	699	3.8	3.5–4.1	1,129	6.2	5.9–6.6	5,273	30.7	29.9–31.5
	F	543	5.7	5.2–6.2	250	2.8	2.5–3.1	324	3.7	3.3–4.1	1,188	14.2	13.4–15.0
	M	721	7.2	6.7–7.8	449	4.8	4.4–5.2	805	8.7	8.1–9.3	4,085	46.3	44.9–47.7
1993	All	1,367	6.9	6.6–7.3	699	3.8	3.5–4.1	1,231	6.7	6.3–7.0	5,400	31.1	30.3–31.9
	F	586	6.1	5.6–6.6	284	3.2	2.8–3.5	395	4.4	3.9–4.8	1,241	14.7	13.9–15.5
	M	781	7.8	7.2–8.3	415	4.4	4.0–4.8	836	8.8	8.2–9.4	4,159	46.6	45.2–48.0
1994	All	1,311	6.7	6.3–7.0	671	3.6	3.3–3.8	1,193	6.4	6.0–6.7	5,655	31.9	31.0–32.7
	F	562	5.8	5.4–6.3	261	2.9	2.5–3.2	373	4.1	3.7–4.5	1,181	13.7	12.9–14.5
	M	749	7.4	6.9–8.0	410	4.3	3.9–4.7	820	8.6	8.0–9.1	4,474	49.1	47.6–50.5
1995	All	1,204	6.2	5.8–6.5	661	3.5	3.2–3.7	1,145	6.1	5.7–6.4	5,424	29.8	29.0–30.6
	F	527	5.5	5.1–6.0	253	2.7	2.4–3.0	357	3.9	3.5–4.3	1,344	15.2	14.4–16.0
	M	677	6.8	6.3–7.3	408	4.2	3.8–4.6	788	8.2	7.6–8.7	4,080	43.6	42.3–44.9
1996	All	1,184	6.1	5.8–6.5	671	3.5	3.2–3.7	1,069	5.6	5.3–6.0	5,143	27.5	26.7–28.2
	F	540	5.7	5.2–6.2	296	3.1	2.8–3.5	337	3.6	3.2–4.0	1,221	13.4	12.7–14.2
	M	644	6.5	6.0–7.0	375	3.8	3.4–4.2	732	7.5	7.0–8.1	3,922	40.8	39.5–42.1
1997	All	1,147	6.0	5.7–6.4	640	3.2	3.0–3.5	1,027	5.4	5.1–5.7	4,996	26.1	25.4–26.8
	F	512	5.5	5.0–6.0	262	2.7	2.4–3.0	358	3.8	3.4–4.2	1,253	13.5	12.7–14.2
	M	635	6.5	6.0–7.0	378	3.7	3.4–4.1	669	6.8	6.3–7.4	3,743	38.0	36.8–39.3
1998	All	1,154	6.1	5.7–6.4	664	3.3	3.1–3.6	1,060	5.5	5.2–5.8	4,802	24.6	23.9–25.3
	F	490	5.3	4.8–5.8	257	2.6	2.3–3.0	338	3.6	3.2–4.0	1,251	13.2	12.4–13.9
	M	664	6.8	6.3–7.4	407	4.0	3.6–4.4	722	7.3	6.8–7.9	3,551	35.3	34.2–36.5
All years	All	12,904	6.7	6.6–6.8	7,049	3.8	3.7–3.8	11,238	6.1	6.0–6.2	53,601	29.6	29.4–29.9
	F	5,675	6.0	5.9–6.2	2,753	3.0	2.9–3.1	3,465	3.9	3.7–4.0	12,705	14.4	14.2–14.7
	M	7,229	7.3	7.2–7.5	4,296	4.5	4.3–4.6	7,773	8.3	8.1–8.5	40,896	44.0	43.6–44.4

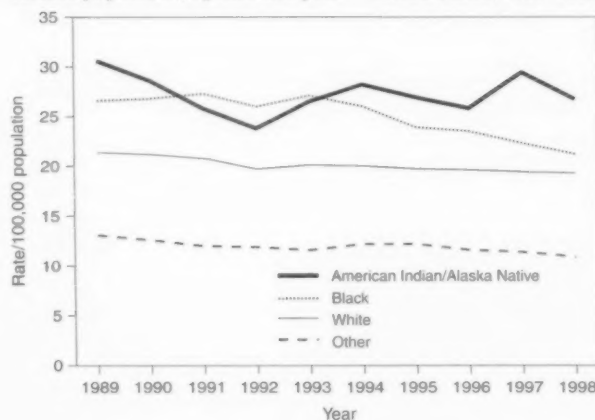
* Confidence interval.

Sex

The TBI-related death rate was three times higher for males, compared with females, with average annual rates of 33.0 and 9.8/100,000 population, respectively (Table 1). During 1989–1998, TBI-related death rates declined 13% among males ($p = <0.01$) and 7% among females ($p = 0.11$). For the surveillance period, TBI-related death rates of males were higher than that of females among all age groups.

Race

TBI-related death rates were highest among American Indian/Alaska Natives at 27.2 deaths/100,000 population (41.5 and 13.8/100,000 among males and females, respectively) (Table 1) (Figure 2). Death rates among this population tended to decrease (13%) during the surveillance period, although this decrease was not statistically significant. Among blacks, the average TBI-related death rate during the surveillance period was 25.0 deaths/100,000 population (42.2 and 10.5/100,000 among males and females, respectively). Among racial populations evaluated, the greatest decrease in TBI-related mortality was observed among blacks (20%), with

FIGURE 2. Age-adjusted traumatic brain injury death rates/100,000 population, by race and year — United States, 1989–1998

the majority of the decrease (19%) occurring in the interval 1994–1998. Among whites, the average TBI-related death rate during the surveillance period was 20.1 deaths/100,000 population (32 and 9.7/100,000 population among males and

TABLE 2. (Continued) Annual numbers and rates/100,000 population for traumatic brain injury deaths by year, age group, and sex — United States, 1989–1998

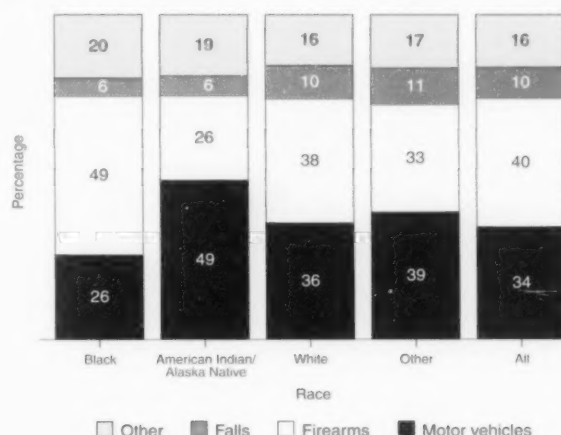
Year		Age														
		25–34 yrs			35–44 yrs			45–54 yrs			55–64 yrs			65–74 yrs		
		No.	Rate	95% CI*	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
1989	All	11,087	25.6	25.2–26.1	7,416	20.4	19.9–20.8	4,890	19.9	19.3–20.4	4,370	20.6	20.0–21.2	4,763	26.7	25.9–27.4
	F	2,303	10.6	10.2–11.1	1,642	8.9	8.5–9.3	1,020	8.1	7.6–8.6	1,035	9.2	8.6–9.8	1,216	12.1	11.4–12.8
	M	8,784	40.7	39.8–41.5	5,774	32.1	31.3–32.9	3,870	32.2	31.2–33.2	3,335	33.3	32.2–34.5	3,547	45.3	43.8–46.8
1990	All	10,979	25.4	25.0–25.9	7,586	20.1	19.6–20.5	4,888	19.4	18.9–19.9	4,252	20.2	19.6–20.8	4,473	24.7	24.0–25.4
	F	2,255	10.4	10.0–10.9	1,581	8.3	7.9–8.7	1,064	8.3	7.8–8.7	967	8.7	8.1–9.2	1,154	11.4	10.7–12.0
	M	8,724	40.5	39.6–41.3	6,005	32.1	31.3–33.0	3,824	31.1	30.1–32.1	3,285	33.0	31.9–34.1	3,319	41.8	40.4–43.2
1991	All	10,481	24.5	24.0–24.9	7,617	19.4	19.0–19.8	4,868	18.9	18.4–19.4	4,134	19.7	19.1–20.3	4,496	24.6	23.9–25.3
	F	2,083	9.7	9.3–10.1	1,583	8.0	7.6–8.4	1,034	7.8	7.4–8.3	853	7.7	7.2–8.2	1,195	11.7	11.0–12.3
	M	8,398	39.2	38.4–40.1	6,034	31.0	30.2–31.8	3,834	30.5	29.5–31.5	3,281	33.0	31.9–34.2	3,301	41.1	39.7–42.5
1992	All	9,738	23.0	22.5–23.4	7,456	18.7	18.3–19.1	4,882	17.8	17.3–18.3	3,950	18.9	18.3–19.5	4,383	23.8	23.1–24.5
	F	1,925	9.1	8.7–9.5	1,595	7.9	7.5–8.3	1,067	7.6	7.2–8.1	905	8.2	7.7–8.8	1,141	11.1	10.4–11.7
	M	7,813	36.9	36.1–37.7	5,861	29.7	28.9–30.4	3,815	28.5	27.6–29.4	3,045	30.7	29.6–31.8	3,242	39.9	38.5–41.3
1993	All	9,954	23.8	23.4–24.3	7,652	18.8	18.3–19.2	5,162	18.0	17.5–18.5	3,934	18.8	18.2–19.4	4,406	23.7	23.0–24.4
	F	2,071	9.9	9.5–10.3	1,676	8.1	7.7–8.5	1,103	7.5	7.1–8.0	850	7.7	7.2–8.3	1,148	11.0	10.4–11.7
	M	7,883	37.8	37.0–38.6	5,976	29.6	28.8–30.3	4,059	29.0	28.1–29.9	3,084	31.1	30.0–32.2	3,258	39.6	38.2–40.9
1994	All	9,441	22.9	22.4–23.4	7,920	19.0	18.6–19.4	5,276	17.7	17.2–18.1	3,863	18.4	17.8–19.0	4,400	23.5	22.8–24.2
	F	1,944	9.4	9.0–9.8	1,694	8.1	7.7–8.4	1,171	7.7	7.2–8.1	838	7.6	7.1–8.1	1,179	11.3	10.7–12.0
	M	7,497	36.5	35.6–37.3	6,226	30.1	29.4–30.9	4,105	28.1	27.3–29.0	3,025	30.3	29.2–31.4	3,221	38.9	37.5–40.2
1995	All	9,106	22.4	21.9–22.8	7,885	18.5	18.1–18.9	5,447	17.5	17.1–18.0	3,810	18.0	17.5–18.6	4,443	23.7	23.0–24.4
	F	1,918	9.4	9.0–9.8	1,782	8.3	7.9–8.7	1,188	7.5	7.0–7.9	831	7.5	7.0–8.0	1,183	11.4	10.7–12.0
	M	7,188	35.4	34.6–36.2	6,103	28.9	28.2–29.7	4,259	28.0	27.2–28.9	2,979	29.7	28.6–30.7	3,260	39.1	37.7–40.4
1996	All	8,574	21.3	20.9–21.8	7,942	18.3	17.9–18.7	5,725	17.7	17.2–18.2	3,980	18.6	18.1–19.2	4,591	24.6	23.9–25.3
	F	1,830	9.1	8.6–9.5	1,792	8.2	7.8–8.6	1,265	7.6	7.2–8.1	891	8.0	7.4–8.5	1,158	11.2	10.5–11.8
	M	6,744	33.7	32.9–34.5	6,150	28.6	27.7–29.3	4,460	28.2	27.4–29.0	3,089	30.4	29.3–31.5	3,433	41.2	39.8–42.6
1997	All	8,248	20.9	20.4–21.3	7,888	17.9	17.5–18.3	5,738	17.1	16.6–17.5	4,075	18.7	18.1–19.3	4,589	24.8	24.1–25.5
	F	1,720	8.6	8.2–9.1	1,857	8.4	8.0–8.8	1,289	7.5	7.1–7.9	901	7.9	7.4–8.4	1,235	12.1	11.4–12.7
	M	6,528	33.2	32.4–34.0	6,031	27.6	26.9–28.3	4,449	27.1	26.3–27.9	3,174	30.6	29.5–31.6	3,354	40.5	39.1–41.9
1998	All	7,668	19.8	19.3–20.2	7,856	17.6	17.3–18.0	5,875	17.0	16.6–17.4	4,182	18.4	17.9–19.0	4,553	24.8	24.0–25.5
	F	1,656	8.5	8.1–8.9	1,884	8.4	8.0–8.8	1,338	7.6	7.2–8.0	935	7.9	7.4–8.4	1,253	12.4	11.7–13.0
	M	6,012	31.2	30.4–32.0	5,972	27.0	26.3–27.7	4,537	26.8	26.1–27.6	3,247	30.0	29.0–31.1	3,300	40.0	38.6–41.4
All years	All	95,276	23.0	22.9–23.2	77,218	18.8	18.7–19.0	52,751	18.0	17.8–18.1	40,550	19.0	18.8–19.2	45,097	24.5	24.2–24.7
	F	19,705	9.5	9.4–9.6	17,086	8.3	8.1–8.4	11,539	7.7	7.6–7.8	9,006	8.0	7.9–8.2	11,862	11.5	11.3–11.8
	M	75,571	36.6	36.3–36.9	60,132	29.6	29.3–29.8	41,212	28.8	28.5–29.1	31,544	31.2	30.9–31.6	33,235	40.7	40.3–41.1

* Confidence interval.

females, respectively). During 1989–1998, a 10% decrease in rates ($p = <0.01$) was observed for whites. Other races and persons with unknown race information (representing 2% of TBI fatalities) were grouped together (Table 1) with an overall death rate of 11.9 deaths/100,000 population (17.2 and 7.2/100,000 population among males and females, respectively). Death rates also decreased 17% among this group during the surveillance period.

Major External Causes of TBI-Related Deaths

For the surveillance period, firearm-related, motor-vehicle-related, and fall-related TBIs were the three leading underlying causes of TBI-related death, accounting for 40%, 34%, and 10%, respectively, of all TBI-related deaths (Figure 3). Other causes, including cases with missing external cause-of-injury codes, accounted for 16%. The leading causes of TBI-related death differed among specific age groups: fatal motor-vehicle injuries were the leading cause of TBI-related

FIGURE 3. Percentage of external cause of injury* among traumatic brain injury deaths, by race — United States, 1989–1998

* External cause of injury: The circumstance or environmental event that caused the injury.

deaths among children and youths aged 0–19 years (62%); fatal firearm-related injuries were the leading cause among adults aged 20–74 years (52%); and fatal fall-related injuries were the leading cause among adults aged ≥75 years (46%) (Figure 4) (Table 3).

Trends by Cause

During 1989–1998, the rates for fall-related TBI deaths increased by 25% (Table 4); whereas the rates for firearm-related TBIs declined by 14% ($p = 0.02$) (Table 5); and the rates for motor-vehicle-related TBIs declined by 22% (Table 6). Shifts occurred in observed trends between the first half and second half of the surveillance period. Firearm-related TBI rates began to decline after 1994. In contrast, motor-vehicle-related TBI rates declined 19% during 1989–1994, but since then have declined only slightly (Figure 5). The rates of fall-related TBIs began to increase in 1995.

FIGURE 4. Average annual death rates of traumatic brain injury, by age group and external cause of injury — United States, 1989–1998

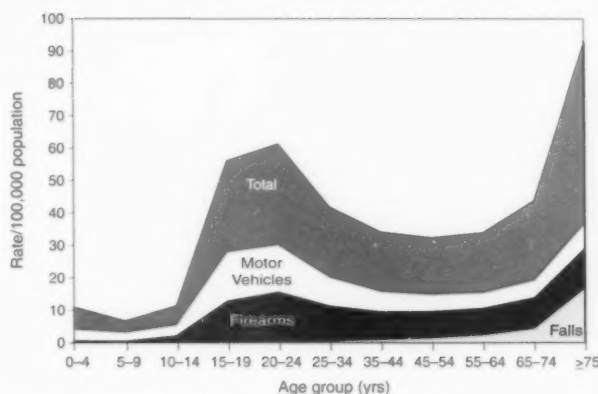


TABLE 3. Annual rates/100,000 population of traumatic brain injury deaths, by cause, age group, and sex — United States, 1989–1998

Age group (yrs)		Falls		Motor vehicle		Firearms		Other/Unknown	
		Rate	95% CI*	Rate	95% CI	Rate	95% CI	Rate	95% CI
0–4	All	0.3	0.3–0.3	3.6	3.5–3.7	0.3	0.3–0.4	2.5	2.4–2.6
	F	0.2	0.2–0.2	3.3	3.2–3.4	0.3	0.2–0.3	2.2	2.1–2.3
	M	0.3	0.3–0.4	3.9	3.8–4.0	0.4	0.3–0.4	2.7	2.6–2.8
5–9	All	0.1	0.1–0.1	2.8	2.8–2.9	0.4	0.3–0.4	0.5	0.4–0.5
	F	0.0	0.0–0.1	2.3	2.2–2.4	0.3	0.3–0.3	0.4	0.3–0.4
	M	0.1	0.1–0.1	3.4	3.2–3.5	0.4	0.4–0.5	0.6	0.5–0.6
10–14	All	0.1	0.1–0.1	3.4	3.4–3.5	2.0	2.0–2.1	0.6	0.5–0.6
	F	0.1	0.0–0.1	2.5	2.4–2.6	0.9	0.8–0.9	0.4	0.4–0.5
	M	0.1	0.1–0.2	4.3	4.2–4.4	3.1	3.0–3.2	0.7	0.7–0.8
15–19	All	0.3	0.3–0.3	15.3	15.1–15.4	12.5	12.3–12.6	1.6	1.5–1.6
	F	0.1	0.1–0.1	10.2	10.0–10.4	3.3	3.2–3.4	0.8	0.7–0.9
	M	0.5	0.5–0.6	20.0	19.7–20.3	21.1	20.8–21.4	2.3	2.2–2.4
20–24	All	0.4	0.4–0.5	14.6	14.4–14.8	15.0	14.8–15.2	2.4	2.3–2.5
	F	0.1	0.1–0.1	6.8	6.7–7.0	3.7	3.6–3.9	1.0	1.0–1.1
	M	0.8	0.7–0.8	22.1	21.8–22.4	25.9	25.6–26.2	3.7	3.6–3.8
25–34	All	0.6	0.6–0.6	9.0	8.9–9.1	10.7	10.6–10.8	2.7	2.7–2.8
	F	0.2	0.1–0.2	4.5	4.4–4.6	3.5	3.4–3.6	1.3	1.3–1.4
	M	1.0	1.0–1.1	13.5	13.3–13.6	18.0	17.8–18.2	4.1	4.0–4.2
35–44	All	1.0	0.9–1.0	6.3	6.3–6.4	8.5	8.4–8.6	3.0	2.9–3.0
	F	0.3	0.3–0.3	3.6	3.5–3.6	3.1	3.0–3.2	1.3	1.2–1.3
	M	1.6	1.6–1.7	9.2	9.1–9.3	14.0	13.9–14.2	4.7	4.6–4.8
45–54	All	1.5	1.4–1.5	5.3	5.3–5.4	8.1	8.0–8.2	3.1	3.0–3.1
	F	0.5	0.5–0.6	3.1	3.0–3.2	2.8	2.7–2.9	1.3	1.2–1.3
	M	2.4	2.4–2.5	7.7	7.5–7.8	13.7	13.5–13.9	5.0	4.9–5.1
55–64	All	2.4	2.3–2.5	4.9	4.8–5.0	8.2	8.1–8.4	3.5	3.4–3.6
	F	1.1	1.1–1.2	3.2	3.1–3.3	2.3	2.2–2.4	1.5	1.4–1.6
	M	3.9	3.7–4.0	6.8	6.6–7.0	14.9	14.6–15.1	5.7	5.5–5.8
65–74	All	4.5	4.4–4.6	5.5	5.4–5.6	9.4	9.3–9.6	5.1	5.0–5.2
	F	2.7	2.6–2.8	4.1	3.9–4.2	2.0	1.9–2.1	2.7	2.6–2.8
	M	6.7	6.5–6.9	7.3	7.1–7.4	18.7	18.4–19.0	8.0	7.8–8.2
≥75	All	17.1	16.9–17.3	8.0	7.8–8.1	12.1	11.9–12.2	16.3	16.1–16.5
	F	13.6	13.3–13.8	5.5	5.3–5.6	1.5	1.4–1.5	11.5	11.3–11.7
	M	23.4	22.9–23.8	12.4	12.1–12.7	30.9	30.4–31.3	24.9	24.5–25.4
All ages	All	2.1	2.1–2.1	7.0	7.0–7.0	8.1	8.1–8.1	3.4	3.4–3.4
	F	1.3	1.2–1.3	4.3	4.2–4.3	2.4	2.3–2.4	2.0	2.0–2.0
	M	3.2	3.2–3.2	9.9	9.9–10.0	14.5	14.5–14.6	4.7	4.7–4.8

* Confidence interval.

TABLE 4. Annual numbers and age-adjusted rates/100,000 population for fall-related traumatic brain injury deaths, by year and race — United States, 1989–1998

Year	White			Black			American Indian/ Alaska Native			Other			Total		
	No.	Rate	95% CI*	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
1989	3,892	1.9	1.9–2.0	493	2.2	2.0–2.4	38	2.8	1.9–3.8	67	2.0	1.4–2.5	4,488	2.0	1.9–2.0
1990	3,878	1.9	1.8–2.0	489	2.1	1.9–2.3	31	2.7	1.6–3.8	73	2.5	1.9–3.1	4,471	1.9	1.9–2.0
1991	4,034	1.9	1.9–2.0	459	2.0	1.8–2.2	35	2.5	1.6–3.4	60	1.6	1.1–2.0	4,588	2.0	1.9–2.0
1992	3,955	1.9	1.8–1.9	401	1.7	1.6–1.9	23	1.7	0.9–2.4	98	2.6	2.0–3.2	4,477	1.9	1.8–1.9
1993	4,109	1.9	1.9–2.0	433	1.8	1.6–2.0	44	2.7	1.9–3.6	75	1.7	1.3–2.1	4,661	1.9	1.9–2.0
1994	4,357	2.0	1.9–2.1	447	1.9	1.7–2.0	36	2.1	1.4–2.9	106	2.3	1.8–2.8	4,946	2.0	1.9–2.1
1995	4,582	2.1	2.0–2.1	432	1.8	1.6–2.0	35	2.0	1.3–2.7	125	2.6	2.1–3.1	5,174	2.0	2.0–2.1
1996	5,062	2.2	2.2–2.3	445	1.8	1.6–2.0	28	1.5	0.9–2.1	112	2.2	1.8–2.7	5,647	2.2	2.1–2.3
1997	5,487	2.4	2.3–2.4	426	1.7	1.6–1.9	48	3.0	2.1–3.9	136	2.5	2.0–2.9	6,097	2.3	2.3–2.4
1998	5,886	2.5	2.4–2.6	459	1.8	1.7–2.0	41	2.4	1.6–3.2	146	2.5	2.1–3.0	6,532	2.5	2.4–2.5
All years	45,242	2.1	2.1–2.1	4,484	1.9	1.8–1.9	357	2.3	2.1–2.6	998	2.3	2.1–2.4	51,081	2.1	2.1–2.1

* Confidence interval.

TABLE 5. Annual numbers and rates/100,000 population for firearm-related suicide and homicide traumatic brain injury deaths, by year and race — United States, 1989–1998

Year	White			Black			American Indian/ Alaska Native			Other			Total		
	No.	Rate	95% CI*	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
1989 All	1,6325	7.7	7.6–7.9	3,519	10.7	10.3–11.0	149	7.0	5.8–8.2	236	3.0	2.6–3.4	20,229	8.1	8.0–8.2
Suicide	12,720	6.1	6.0–6.2	884	3.0	2.8–3.2	92	4.3	3.3–5.2	105	1.3	1.1–1.6	13,801	5.6	5.5–5.7
Homicide	2,771	1.3	1.2–1.3	2,454	7.2	6.9–7.5	34	1.8	1.1–2.4	115	1.5	1.2–1.7	5,374	2.0	2.0–2.1
1990 All	17,173	8.1	8.0–8.2	3,803	11.4	11.0–11.8	143	6.5	5.4–7.7	250	3.1	2.7–3.5	21,369	8.5	8.3–8.6
Suicide	13,301	6.3	6.2–6.4	918	3.1	2.9–3.3	94	4.3	3.3–5.2	125	1.6	1.3–1.9	14,438	5.8	5.7–5.9
Homicide	3,054	1.4	1.4–1.5	2,686	7.8	7.5–8.1	33	1.5	1.0–2.0	110	1.4	1.1–1.6	5,883	2.2	2.2–2.3
1991 All	17,289	8.1	8.0–8.2	4,251	12.4	12.0–12.8	150	6.9	5.7–8.1	308	3.7	3.2–4.1	21,998	8.6	8.5–8.8
Suicide	13,141	6.2	6.1–6.3	925	3.0	2.8–3.3	93	4.5	3.5–5.4	135	1.7	1.4–2.0	14,294	5.7	5.6–5.8
Homicide	3,256	1.5	1.4–1.5	3,093	8.7	8.4–9.0	37	1.7	1.1–2.2	167	1.9	1.6–2.2	6,553	2.5	2.4–2.5
1992 All	17,085	7.9	7.8–8.1	4,420	12.6	12.2–13.0	105	4.9	3.9–5.9	310	3.8	3.2–4.1	21,920	8.5	8.4–8.6
Suicide	12,880	6.0	5.9–6.1	970	3.0	2.8–3.2	66	3.3	2.4–4.1	142	1.8	1.5–2.1	14,058	5.6	5.5–5.6
Homicide	3,335	1.5	1.5–1.6	3,185	8.9	8.5–9.2	25	1.1	0.6–1.5	149	1.6	1.4–1.9	6,694	2.5	2.5–2.6
1993 All	17,651	8.1	8.0–8.3	4,611	13.1	12.7–13.5	147	6.8	5.6–7.9	331	3.5	3.1–3.9	22,740	8.8	8.7–8.9
Suicide	13,344	6.2	6.1–6.3	1,060	3.3	3.1–3.5	96	4.6	3.6–5.5	139	1.6	1.3–1.8	14,639	5.7	5.6–5.8
Homicide	3,301	1.5	1.5–1.6	3,262	9.0	8.7–9.4	39	1.7	1.2–2.3	171	1.8	1.5–2.0	6,773	2.5	2.5–2.6
1994 All	17,417	8.0	7.9–8.1	4,504	12.7	12.3–13.0	167	7.1	6.0–8.2	325	3.4	3.0–3.8	22,413	8.6	8.5–8.7
Suicide	13,302	6.1	6.0–6.2	1,074	3.3	3.1–3.5	107	4.6	3.7–5.5	174	1.8	1.6–2.1	14,657	5.7	5.6–5.8
Homicide	3,223	1.5	1.4–1.5	3,149	8.7	8.4–9.0	45	1.9	1.3–2.5	131	1.3	1.1–1.6	6,548	2.5	2.4–2.5
1995 All	17,002	7.7	7.6–7.8	3,795	10.7	10.3–11.0	175	7.3	6.2–8.4	327	3.3	2.9–3.6	21,299	8.1	8.0–8.2
Suicide	13,282	6.0	5.9–6.1	988	3.0	2.8–3.2	97	4.1	3.3–5.0	165	1.7	1.4–1.9	14,532	5.6	5.5–5.6
Homicide	2,938	1.3	1.3–1.4	2,590	7.1	6.8–7.4	59	2.5	1.8–3.1	145	1.4	1.2–1.7	5,732	2.1	2.1–2.2
1996 All	16,167	7.3	7.2–7.4	3,752	10.5	10.1–10.8	147	6.0	5.0–7.0	269	2.6	2.3–2.9	20,335	7.7	7.6–7.8
Suicide	12,881	5.8	5.7–5.9	1,022	3.1	2.9–3.3	95	4.0	3.2–4.9	140	1.4	1.1–1.6	14,138	5.4	5.3–5.4
Homicide	2,521	1.1	1.1–1.2	2,509	6.8	6.5–7.1	36	1.4	0.9–1.8	119	1.1	0.9–1.3	5,185	1.9	1.9–2.0
1997 All	15,811	7.1	7.0–7.2	3,368	9.2	8.9–9.5	154	6.5	5.4–7.6	292	2.9	2.5–3.2	19,625	7.3	7.2–7.4
Suicide	12,715	5.7	5.6–5.8	961	2.8	2.7–3.0	100	4.3	3.4–5.1	171	1.7	1.4–2.0	13,947	5.2	5.1–5.3
Homicide	2,432	1.1	1.1–1.1	2,246	6.0	5.7–6.2	38	1.6	1.0–2.1	111	1.1	0.9–1.3	4,827	1.8	1.7–1.8
1998 All	15,431	6.8	6.7–6.9	3,002	8.2	7.9–8.5	175	7.1	6.0–8.2	280	2.7	2.4–3.0	18,888	7.0	6.9–7.1
Suicide	12,682	5.6	5.5–5.7	872	2.5	2.4–2.7	115	4.8	3.9–5.7	170	1.7	1.4–2.0	13,839	5.1	5.0–5.2
Homicide	2,168	1.0	0.9–1.0	1,957	5.2	5.0–5.4	44	1.7	1.2–2.2	104	1.0	0.8–1.1	4,273	1.6	1.5–1.6
All years All	167,351	7.7	7.6–7.7	39,025	11.1	11.0–11.2	1,512	6.6	6.3–7.0	2,928	3.2	3.0–3.3	210,816	8.1	8.1–8.1
Suicide	130,248	6.0	5.9–6.0	9,674	3.0	2.9–3.1	955	4.3	4.0–4.6	1,466	1.6	1.5–1.7	142,343	5.5	5.5–5.6
Homicide	28,999	1.3	1.3–1.3	27,131	7.5	7.4–7.6	390	1.7	1.5–1.8	1,322	1.4	1.3–1.5	57,842	2.2	2.1–2.2

* Confidence interval.

Firearm-Related TBI Deaths by Age, Sex, Intentionality, and Race

The highest firearm-related TBI death rates were among persons aged 20–24 years (Table 3). The majority of firearm-related TBI deaths involved males (85%), among whom the death rate was substantially greater than among females (14.5 versus 2.4/100,000 population, respectively).

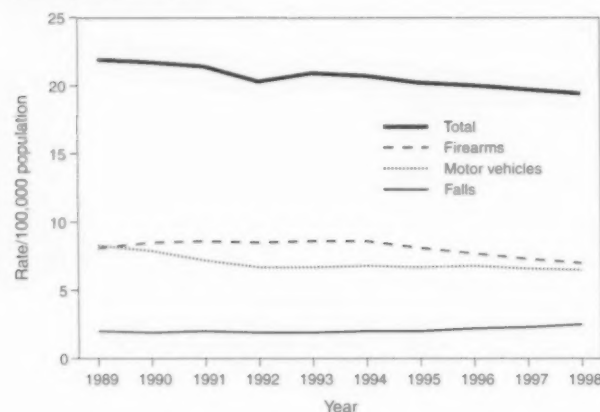
Among all firearm-related TBI deaths; 68% were suicides; 27% were homicides (Table 5); and 5% were either unintentional, of unknown intentionality, or related to legal intervention. During 1989–1998, death rates for TBI involving firearms decreased 20% for homicides and 9% for suicides ($p < 0.01$).

TABLE 6. Annual numbers and age-adjusted rates/100,000 population for motor-vehicle-related traumatic brain injury deaths, by year and race — United States, 1989–1998

Year	White			Black			American Indian/ Alaska Native			Other			Total		
	No.	Rate	95% CI*	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
1989	18,282	8.5	8.4–8.6	2,234	7.2	6.9–7.5	307	14.5	12.8–16.3	347	5.0	4.4–5.6	21,170	8.3	8.1–8.4
1990	17,449	8.1	8.0–8.2	2,175	6.9	6.6–7.2	292	13.5	11.8–15.2	349	5.0	4.4–5.6	20,265	7.9	7.8–8.0
1991	16,150	7.5	7.4–7.6	2,031	6.4	6.1–6.6	241	10.9	9.4–12.3	315	4.1	3.6–4.5	18,737	7.2	7.1–7.4
1992	14,744	6.8	6.7–7.0	1,952	6.1	5.8–6.4	262	11.7	10.2–13.2	312	3.9	3.4–4.3	17,270	6.7	6.6–6.8
1993	15,016	6.9	6.8–7.0	2,042	6.2	6.0–6.5	275	12.0	10.5–13.6	305	3.8	3.3–4.3	17,638	6.7	6.6–6.8
1994	15,098	7.0	6.8–7.1	2,023	6.1	5.9–6.4	283	12.4	10.9–13.9	361	4.2	3.8–4.7	17,765	6.8	6.7–6.9
1995	14,917	6.8	6.7–6.9	2,032	6.0	5.8–6.3	309	12.8	11.4–14.3	371	4.2	3.7–4.7	17,629	6.7	6.6–6.8
1996	15,222	6.9	6.8–7.0	2,087	6.1	5.9–6.4	303	13.0	11.4–14.5	396	4.2	3.8–4.6	18,008	6.8	6.7–6.9
1997	15,069	6.8	6.7–6.9	2,122	6.3	6.0–6.5	283	12.1	10.6–13.6	372	3.9	3.4–4.3	17,846	6.6	6.5–6.7
1998	14,958	6.7	6.6–6.8	2,131	6.2	5.9–6.4	297	11.9	10.5–13.3	342	3.4	3.0–3.8	17,728	6.5	6.4–6.6
All years	156,905	7.2	7.2–7.3	20,829	6.3	6.3–6.4	2,852	12.5	12.0–12.9	3,470	4.1	4.0–4.3	184,056	7.0	7.0–7.0

* Confidence interval.

FIGURE 5. Age-adjusted traumatic brain injury death rates/100,000 population by external cause of injury — United States, 1989–1998



Firearm-related TBI death rates varied substantially by race (Tables 5 and 7). Firearm-related injury was the leading cause of TBI-related deaths among blacks, and 70% of these were homicides; rates were highest among males aged 20–24 years (60.7/100,000 population) (Table 7). During 1989–1998, firearm-related TBI death rates among blacks declined by 23%, although not statistically significant. Among whites, firearm-related injury was also the leading underlying cause of TBI-related deaths; 78% were suicides. Firearm-related TBI death rates were highest among white males aged 20–24 years (20.6/100,000) and white males aged ≥ 75 years (33.0/100,000). Firearm-related TBI rates among whites declined 12% ($p = 0.01$). Among American Indian/Alaska Natives, firearm-related injury was the second leading cause of TBI-related deaths; 63% of these were suicides. Rates were also highest among males aged 20–24 years (26.2/100,000). During 1989–1998, rates of firearm-related TBI deaths increased slightly (1%) among American Indians/Alaska Natives.

Motor-Vehicle-Related TBI Deaths by Age, Sex, and Race

The highest motor-vehicle-related TBI death rates were among persons aged 15–19 (15.3/100,000) and 20–24 (14.6/100,000) years (Table 3). The overall incidence among males was > 2 times that among females (9.9 and 4.3/100,000 population, respectively).

Rates of motor-vehicle-related TBI deaths varied by race (Tables 6 and 8). The annual average rate among whites was 7.2/100,000, and the annual rate declined 21% during 1989–1998 ($p = < 0.01$). Among blacks, the average annual rate of these injuries was 6.3/100,000, with a 14% decline during the same period ($p = 0.02$). The average annual motor-vehicle-related TBI death rate among American Indians/Alaska Natives was higher at 12.5/100,000, with an 18% decline during 1989–1998. This rate decline was not statistically significant ($p = 0.33$). For each of these races, rates of motor-vehicle-related TBI death were highest among males aged 20–24 years: 23.4/100,000 for white males, 17.1/100,000 for black males, and 35.0/100,000 for American Indian/Alaskan Native males.

Fall-Related TBI Deaths by Age, Sex, and Race

Among persons aged ≥ 75 years, falls were the leading cause of fatal TBIs for blacks, American Indians/Alaska Natives, and whites (Table 9). Compared with annual fall-related TBI death rates for persons aged < 65 years, the rate ratio of fatal fall-related TBIs was 5.6 for persons aged 65–74 years, and 21.4 for persons aged ≥ 75 years. Death rates among persons with these injuries were considerably higher among males than females (3.2 and 1.3/100,000 population, respectively).

During the surveillance period, the average rate among whites was 2.1/100,000, with an increase of 32%. Among blacks, the average annual rate of these injuries was 1.9/100,000, with an 18% decline during the same period

TABLE 7. Annual rates/100,000 population for firearm-related traumatic brain injury deaths, by age group and race — United States, 1989–1998

Age group (yrs)		White		Black		American Indian/Alaska Native		Other	
		Rate	95% CI*	Rate	95% CI	Rate	95% CI	Rate	95% CI
0–4	All	0.2	0.2–0.3	0.8	0.7–0.9	—†		0.3	0.1–0.4
	F	0.2	0.2–0.2	0.7	0.5–0.8	—		—	
	M	0.3	0.2–0.3	1.0	0.8–1.1	—		—	
5–9	All	0.3	0.3–0.3	0.7	0.6–0.8	0.9	0.5–1.3	0.3	0.2–0.4
	F	0.2	0.2–0.3	0.5	0.3–0.6	—		—	
	M	0.3	0.3–0.3	1.0	0.8–1.1	—		—	
10–14	All	1.8	1.7–1.9	3.5	3.3–3.7	2.1	1.5–2.7	1.2	1.0–1.5
	F	0.7	0.7–0.8	1.7	1.5–2.0	—		0.6	0.4–0.9
	M	2.8	2.7–2.9	5.2	4.8–5.5	3.7	2.6–4.9	1.8	1.3–2.2
15–19	All	9.8	9.6–9.9	27.7	27.1–28.3	13.6	12.0–15.2	6.8	6.2–7.5
	F	2.8	2.6–2.9	6.4	6.0–6.8	3.5	2.4–4.7	1.8	1.4–2.3
	M	16.3	16.1–16.6	48.5	47.4–49.7	23.3	20.4–26.3	11.6	10.5–12.8
20–24	All	12.0	11.8–12.2	33.9	33.2–34.6	15.1	13.4–16.9	7.5	6.9–8.1
	F	3.0	2.9–3.2	7.9	7.5–8.4	3.3	2.1–4.5	2.5	1.9–3.0
	M	20.6	20.2–20.9	60.7	59.4–62.0	26.2	23.0–29.5	12.5	11.3–13.6
25–34	All	9.5	9.4–9.6	20.1	19.7–20.5	10.9	9.8–11.9	4.6	4.2–4.9
	F	3.1	3.0–3.2	6.5	6.2–6.8	3.5	2.6–4.4	1.8	1.5–2.1
	M	15.9	15.7–16.0	35.2	34.5–36.0	18.1	16.2–20.0	7.6	7.0–8.2
35–44	All	8.4	8.3–8.5	10.7	10.4–11.0	8.4	7.4–9.4	3.2	3.0–3.5
	F	3.1	3.0–3.1	3.8	3.5–4.0	3.4	2.5–4.2	1.7	1.4–2.0
	M	13.8	13.6–14.0	18.6	18.0–19.2	13.6	11.8–15.5	5.0	4.5–5.5
45–54	All	8.5	8.3–8.6	7.1	6.8–7.4	4.5	3.6–5.4	2.8	2.4–3.1
	F	2.9	2.8–3.0	2.3	2.0–2.5	2.1	1.2–2.9	1.3	0.9–1.6
	M	14.1	13.9–14.4	13.0	12.4–13.6	7.1	5.4–8.7	4.5	3.9–5.1
55–64	All	8.8	8.6–8.9	5.2	4.9–5.6	4.9	3.7–6.1	2.8	2.4–3.2
	F	2.4	2.3–2.5	1.5	1.3–1.7	—		1.0	0.7–1.4
	M	15.7	15.4–16.0	10.1	9.5–10.8	8.7	6.3–11.0	4.9	4.1–5.8
65–74	All	10.0	9.9–10.2	5.3	4.9–5.6	5.5	3.9–7.2	1.9	1.5–2.3
	F	2.1	2.0–2.2	1.5	1.2–1.7	—		—	
	M	19.8	19.5–20.2	10.6	9.9–11.4	10.2	6.9–13.5	3.9	2.9–4.8
≥75	All	12.9	12.7–13.1	4.6	4.2–5.0	—		2.3	1.7–3.0
	F	1.5	1.4–1.6	1.0	0.8–1.3	—		—	
	M	33.0	32.5–33.5	11.4	10.3–12.4	—		4.6	3.2–6.0
All ages	All	7.7	7.6–7.7	11.1	11.0–11.2	6.6	6.3–7.0	3.2	3.0–3.3
	F	2.2	2.2–2.3	3.3	3.2–3.4	2.1	1.9–2.4	1.2	1.1–1.3
	M	13.8	13.7–13.9	19.8	19.6–20.0	11.3	10.6–11.9	5.3	5.0–5.5

* Confidence interval.

† <20 deaths and therefore, unstable rate.

($p = 0.01$) (Table 4). Among American Indians/Alaska Natives, the corresponding average annual rate was 2.3/100,000 population. The limited annual number of fall-related TBI deaths among this group precluded a reliable assessment of the change in race-specific rates during 1989–1998.

Discussion

The data presented in this report document an overall decline in rates of TBI-related deaths in the United States during 1989–1998. During 1980–1995, an even steeper decline was observed in rates of hospital admission as a result of TBI (32). Multiple factors might have contributed to the declines in TBI-related mortality. For example, these decreasing

rates might result in part from improvements in the medical care of severely brain-injured patients, perhaps influenced by evidence-based guidelines, which were developed and disseminated during the surveillance period (33,34), for emergency and acute management of TBIs. However, the decline in rates of TBI-related deaths closely parallels the 9.1% decline in age-adjusted rates of injury death of all types that occurred during the same period (35), indicating that the decrease in TBI-related death rates might be attributed in part to success in general injury-prevention efforts. Effective interventions have resulted in increases in use of seatbelts and child safety seats. Examples of strategies that have demonstrated success include primary enforcement of restraint laws, graduated licensing of new drivers, and community-based health education campaigns (36,37).

TABLE 8. Annual rates/100,000 population for motor-vehicle-related traumatic brain injury deaths, by age group and race — United States, 1989–1998

Age group (yrs)		White		Black		American Indian/Alaska Native		Other	
		Rate	95% CI*	Rate	95% CI	Rate	95% CI	Rate	95% CI
0–4	All	3.4	3.3–3.5	4.9	4.6–5.1	9.8	8.4–11.1	2.1	1.7–2.4
	F	3.1	3.0–3.2	4.5	4.1–4.8	8.5	6.7–10.2	1.9	1.4–2.3
	M	3.6	3.5–3.8	5.3	4.9–5.6	11.1	9.1–13.1	2.2	1.7–2.7
5–9	All	2.7	2.6–2.8	3.6	3.4–3.8	4.2	3.4–5.1	2.0	1.7–2.3
	F	2.2	2.1–2.3	2.8	2.5–3.0	4.6	3.3–5.8	1.4	1.0–1.7
	M	3.2	3.0–3.3	4.4	4.1–4.8	4.0	2.8–5.1	2.6	2.1–3.2
10–14	All	3.6	3.5–3.7	2.9	2.7–3.1	5.1	4.2–6.0	1.8	1.5–2.1
	F	2.7	2.6–2.8	1.8	1.6–2.0	4.2	3.0–5.4	1.6	1.2–2.0
	M	4.5	4.3–4.6	4.0	3.7–4.3	6.0	4.5–7.4	2.0	1.6–2.5
15–19	All	17.0	16.7–17.2	8.2	7.9–8.6	20.4	18.4–22.4	6.6	6.0–7.2
	F	11.7	11.4–11.9	4.1	3.7–4.4	14.5	12.1–16.9	4.7	3.9–5.4
	M	22.0	21.6–22.3	12.3	11.7–12.9	26.1	23.0–29.2	8.5	7.5–9.5
20–24	All	15.5	15.3–15.7	10.8	10.4–11.2	24.7	22.4–27.0	6.9	6.3–7.5
	F	7.3	7.1–7.5	4.7	4.3–5.0	13.8	11.3–16.2	4.5	3.8–5.2
	M	23.4	23.1–23.7	17.1	16.4–17.8	35.0	31.3–38.8	9.2	8.2–10.2
25–34	All	9.2	9.1–9.3	8.4	8.2–8.7	18.8	17.4–20.2	4.1	3.8–4.4
	F	4.7	4.6–4.8	3.8	3.6–4.0	11.2	9.7–12.7	2.3	2.0–2.6
	M	13.6	13.5–13.8	13.5	13.1–14.0	26.2	23.9–28.6	6.0	5.5–6.6
35–44	All	6.4	6.3–6.5	6.7	6.5–6.9	13.0	11.8–14.2	3.2	2.9–3.5
	F	3.6	3.6–3.7	3.1	2.9–3.3	6.6	5.3–7.8	2.5	2.1–2.8
	M	9.1	8.9–9.2	10.8	10.4–11.2	19.7	17.5–21.9	3.9	3.5–4.4
45–54	All	5.3	5.2–5.4	5.9	5.6–6.2	11.4	9.9–12.8	3.3	3.0–3.7
	F	3.2	3.1–3.3	2.7	2.4–2.9	7.1	5.5–8.7	2.7	2.2–3.1
	M	7.5	7.4–7.7	9.8	9.3–10.3	15.9	13.5–18.4	4.1	3.5–4.7
55–64	All	4.9	4.8–5.0	5.2	4.9–5.6	8.6	7.0–10.2	4.0	3.5–4.5
	F	3.2	3.1–3.3	2.7	2.4–3.0	5.1	3.4–6.8	3.2	2.6–3.9
	M	6.6	6.5–6.8	8.6	8.0–9.2	12.5	9.7–15.3	5.0	4.1–5.8
65–74	All	5.4	5.3–5.6	5.6	5.2–6.0	8.8	6.7–10.8	5.9	5.1–6.7
	F	4.1	4.0–4.3	3.1	2.8–3.5	4.7	2.7–6.7	4.8	3.8–5.7
	M	7.1	6.9–7.2	9.1	8.4–9.8	13.8	9.9–17.6	7.4	6.1–8.7
≥75	All	8.1	8.0–8.3	6.2	5.7–6.7	8.4	6.0–10.9	8.1	6.9–9.3
	F	5.7	5.5–5.9	3.1	2.7–3.5	—†	—	5.6	4.2–6.9
	M	12.4	12.1–12.7	12.1	11.0–13.2	13.1	8.2–18.1	11.4	9.2–13.6
All ages	All	7.2	7.2–7.3	6.3	6.3–6.4	12.5	12.0–12.9	4.1	4.0–4.3
	F	4.4	4.4–4.5	3.3	3.2–3.3	7.8	7.3–8.3	3.0	2.8–3.2
	M	10.1	10.0–10.2	10.0	9.8–10.2	17.4	16.5–18.2	5.3	5.1–5.6

* Confidence interval.

† <20 deaths and therefore, unstable rate.

During 1989–1998, a shift occurred in the distribution and trends of external causes of TBI. Most importantly, fall-related TBI death rates have steadily increased since 1995. This increase warrants a closer examination of the circumstances leading to these fatal fall injuries (1,19,27). To determine if changes during the surveillance period in the age distribution of persons aged ≥75 years might have accounted for this increasing TBI-related death rate, the ≥75 age group was further categorized into those aged 75–79 years, 80–84 years, and ≥85 years. The findings remained consistent for the subgroups of persons aged ≥75 years. Although the data indicated that age-specific rates have increased most among the oldest age groups, the reasons are unknown. Part of the increase might be caused by more complete TBI diagnosis among older adults as a result of greater use of brain-imaging procedures (38). Also, changes might have occurred in

reporting fall-related events on death certificates (i.e., physicians might now be coding more fall-related events). A possibility also exists of changes in the prevalence of intrinsic (e.g., muscle strength, gait, and cognitive impairment) and extrinsic (e.g., stairs, lack of safety features in bathrooms, worn out carpets that can cause a person to trip, and slippery surfaces) risk factors for falls among the older population (39–43), which might have contributed to the increase in fall-related TBI deaths. Additionally, such risk factors as health behaviors, medication use, comorbid conditions, and those for hemorrhagic complications of TBI (e.g., anticoagulant or platelet-inhibiting medications) (44–47) might also have an effect. Appropriate prevention efforts will require better understanding of the specific circumstances leading to falls among older persons.

TABLE 9. Annual rates/100,000 population for fall-related traumatic brain injury deaths, by age group and race — United States, 1989–1998

Age group (yrs)		White		Black		American Indian/Alaska Native		Other	
		Rate	95% CI*	Rate	95% CI	Rate	95% CI	Rate	95% CI
0–4	All	0.2	0.2–0.3	0.5	0.4–0.5	—†		—	
	F	0.2	0.2–0.2	0.4	0.3–0.5	—		—	
	M	0.3	0.3–0.3	0.5	0.4–0.7	—		—	
5–9	All	0.1	0.1–0.1	0.1	0.1–0.1	—		—	
	F	0.0	0.0–0.1	—		—		—	
	M	0.1	0.1–0.1	—		—		—	
10–14	All	0.1	0.1–0.1	—		—		—	
	F	0.1	0.0–0.1	—		—		—	
	M	0.2	0.1–0.2	—		—		—	
15–19	All	0.4	0.3–0.4	0.1	0.1–0.1	—		—	
	F	0.1	0.1–0.1	—		—		—	
	M	0.6	0.5–0.6	0.1	0.1–0.2	—		—	
20–24	All	0.5	0.5–0.5	0.2	0.2–0.3	—		—	
	F	0.1	0.1–0.1	—		—		—	
	M	0.9	0.8–0.9	0.4	0.3–0.5	—		—	
25–34	All	0.6	0.6–0.6	0.6	0.6–0.7	1.2	0.9–1.6	0.2	0.2–0.3
	F	0.2	0.1–0.2	0.2	0.1–0.2	—		—	
	M	1.1	1.0–1.1	1.1	1.0–1.3	2.2	1.5–2.9	0.4	0.3–0.5
35–44	All	0.9	0.9–0.9	1.6	1.5–1.7	2.0	1.5–2.4	0.4	0.3–0.5
	F	0.3	0.3–0.3	0.4	0.4–0.5	—		—	
	M	1.5	1.4–1.6	2.9	2.7–3.1	3.4	2.5–4.4	0.7	0.5–0.9
45–54	All	1.4	1.3–1.4	2.4	2.2–2.6	3.6	2.8–4.4	0.7	0.5–0.8
	F	0.5	0.5–0.6	0.7	0.6–0.8	—		—	
	M	2.2	2.2–2.3	4.5	4.1–4.8	6.2	4.6–7.7	1.0	0.7–1.3
55–64	All	2.3	2.3–2.4	3.1	2.9–3.4	4.3	3.1–5.4	1.7	1.4–2.0
	F	1.1	1.1–1.2	1.0	0.8–1.2	—		0.7	0.4–1.0
	M	3.7	3.5–3.8	5.9	5.4–6.3	7.7	5.5–9.9	2.9	2.2–3.5
65–74	All	4.5	4.4–4.6	4.2	3.9–4.5	5.2	3.6–6.7	4.9	4.2–5.6
	F	2.8	2.7–2.9	2.2	1.9–2.5	—		3.2	2.5–4.0
	M	6.6	6.4–6.8	7.1	6.5–7.8	9.4	6.2–12.5	7.2	5.9–8.4
≥75	All	17.6	17.4–17.9	9.7	9.1–10.3	8.6	6.1–11.1	23.7	21.6–25.8
	F	14.0	13.8–14.3	7.6	7.0–8.2	7.3	4.4–10.2	17.8	15.4–20.2
	M	24.0	23.6–24.5	13.7	12.5–14.9	10.7	6.2–15.2	31.3	27.7–34.9
All ages	All	2.1	2.1–2.1	1.9	1.8–1.9	2.3	2.1–2.6	2.3	2.1–2.4
	F	1.3	1.3–1.3	0.9	0.9–1.0	1.0	0.8–1.2	1.5	1.4–1.7
	M	3.2	3.1–3.2	3.2	3.1–3.3	3.8	3.3–4.3	3.2	3.0–3.5

* Confidence interval.

† <20 deaths and therefore, unstable rate.

For the total population, firearm-related TBI death rates, which had been increasing until 1994, are now declining. These declines are consistent with declines in the rates of fatal and nonfatal firearms injuries across all population subgroups in the United States (48–51). The circumstances of those firearm-related TBI deaths differ by population: white males are at highest risk for suicide-related TBI (i.e., firearm-related suicides), whereas young black males are at highest risk for homicide. Violence-prevention efforts need to identify these groups most at risk and focus on modifying risk behaviors.

Motor-vehicle-related TBI death rates have demonstrated only a limited change since 1994. This trend parallels the limited decrease in death rates related to all motor-vehicle-related deaths, which have also exhibited limited decrease since 1994 (49). Data from the National Highway Traffic Safety

Administration indicate that since 1994, further decreases have occurred in the proportions of fatal crashes without occupant restraint use and further decreases in the proportions involving alcohol use (52). However, during this period, the distribution of fatal injuries by vehicle types has shifted. During 1994–1998, the number of persons killed in passenger cars decreased 4%, and those injured decreased 7%. Conversely, the number of persons killed and those injured in light trucks* increased by 20% and 21%, respectively. More light trucks are in use, whereas the number of passenger cars is decreasing. Because the rates of fatal crashes are higher in light trucks than in passenger cars (light trucks have fewer

* Light trucks include pickups, vans, and utility vehicles with a gross vehicle weight rating of ≤10,000 pounds.

required safety features compared with cars) (52), safety features of these vehicles should be enhanced through such mechanisms as technological advances, engineering solutions, or behavioral change strategies (53).

Despite the decline in fatal TBI incidence during the surveillance period, the actual number of deaths has not decreased. In addition, population groups with the highest TBI-related death rates have also not changed (1,4,19). TBI-related mortality remains a key public health challenge. Public health and transportation safety professionals can address these challenges by developing comprehensive injury-prevention programs and by implementing multiple interventions based on a thorough assessment of the factors that influence health-related behaviors. Injury-prevention programs should take a multidisciplinary approach to solving injury problems and should enlist the public as full partners in finding and implementing solutions (53).

Limitations

Certain limitations are associated with using the NCHS Multiple Cause of Death data to describe fatal TBI trends. Race/ethnicity data might be misclassified because this information is provided by funeral directors on the basis of next-of-kin or other informant communication or through observation (54–56). Data are less reliable for certain groups than others. In particular, data for American Indian/Alaska Native populations are underestimated by $\leq 21\%$, whereas rates for white and black populations are estimated to be overstated by 1%–5% (55). Because TBI-related deaths were identified where any of the TBI diagnostic codes appeared in a series of events leading to death, the accuracy and reliability of codes are dependent on accurate diagnoses and on the care with which these diagnoses are recorded on death certificates by physicians, medical examiners, or coroners (54). The quality of medical certification on death certificates has not been evaluated fully (54). Additionally, because TBI-related deaths were selected where ≥ 1 TBI diagnostic code was included in the sequence of conditions leading to death, not all of the deaths that are associated with TBI constitute deaths that are actually a result of TBI.

Lack of a narrative text in the NCHS Multiple Cause of Death data is also a limitation because critical circumstances contributing to injury might not be recorded. The original death certificate does include a narrative describing the injury. Nosologists review these narratives to ensure that the causes of death are correctly classified. However, the narrative is not retained on the public use data set.

Lastly, the NCHS Multiple Cause of Death data do not reflect other adverse health effects of TBI (e.g., disability and nonfatal TBI). Although fatal TBI reflects injuries of the greatest severity, annually, >1 million visits are made to hospital emergency departments for TBI-related injuries (57); $>230,000$ TBI-related hospitalizations occur (4); and an estimated 5.3 million U.S. residents live with permanent TBI-related disabilities (27).

Conclusion

The findings presented in this report document continued deaths from TBIs among the U.S. population, a burden that varies substantially among sex, age, and racial groups. These data also demonstrate an increase in deaths from fall-related TBIs. Although strategies for preventing and managing falls among older adults have been developed (58,59), further research is essential to guide development of more effective prevention strategies. As a first step toward achieving greater reductions in TBI mortality and morbidity, dissemination of these findings is critical to public health and injury-control professionals, policy makers, those at high risk, and the general public.

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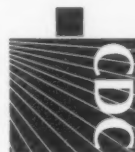
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